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ABSTRACT

Development of problem-solving and creative thinking ability was examined through administration of experimental tasks to 240 gifted children (grade 2 to grade 6). Different patterns of development were noted: problem-solving skills grew steadily from grade 2 through grade 6; while creative thinking increased from grade 2 through grade 4, with no significant increase thereafter. A comparison of scores on problem-solving and creative thinking tasks for 160 nongifted children (grade 5) with those of the gifted Ss revealed that the gifted Ss were approximately two years ahead of the nongifted Ss on all measures. (IM)

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Developmental Patterns in Problem Solving and Creative Thinking Abilities in Gifted Elementary School Children

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Interest in the teaching of creative thinking and problem solving skills has increased considerably over the past 25 years (Stein, 1974). These skills have been considered especially critical components in the education of the gifted child (Gallagher, 1975). An essential foundation for teaching creative thinking and problem solving skills involves understanding developmental trends underlying the growth of these abilities in children. Wallach and Kogan (1965) and Torrance (1966) have demonstrated only a moderately positive relationship between intelligence scores and scores on creative thinking batteries, while in the very high ranges of intelligence scores (above 120), very little or no correlation is reported between IQ and creativity. However, relatively little developmental work in the area of problem solving and creativity has been reported on gifted elementary school children.

Some developmental literature exists on children's performance on creativity tests. Torrance (1967) studied creative development in elementary school children in a cross-cultural context to determine if discontinuities in creativity that typically occur around the fourth grade in the United States, as demonstrated in a number of studies, have natural or

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environmental origins. His findings support the idea that cultural factors, especially educational ones, more strongly influence "the course of creative development, the level of creative functioning, and the type of creative functioning that flourishes most" (Torrance, 1975, p. 211).

On the other hand, Johnson (1972) found no reversals or discontinuities in the development of problem solving skills that would parallel the discontinuities found in creativity research. He cites numerous studies on the development of problem solving skills, indicating their growth in tandem with the child's increasing capacity to handle abstract relationships.

The purpose of this study was to examine several aspects of problem solving and creative thinking in gifted children from a developmental perspective: 1) gifted elementary school children, grades 2-6, were compared for continuities and discontinuities in their performance on creative thinking and problem solving measures; 2) the rate of development of these abilities in the gifted sample was compared with a sample of nongifted fifth grade children; and 3) profiles of performance on the tasks were examined to evaluate the intra-individual variability of the children's performance.

Method

Sample

A sample of 233 second through sixth grade children (identified as gifted by their scores on the Stanford-Binet or Wechsler individual intelligence tests) served as subjects

for this study. There were 58 children in second grade, 48 in third, 45 in fourth, 47 in fifth, and 35 in sixth grade. The children all attend a special school for the gifted, Hunter College Elementary School, located in Manhattan.* The children represent in microcosm the ethnic makeup of Manhattan. Both academic acceleration and cultural enrichment are provided for the children.

Procedures

All of the problem solving, creativity, and affective measures were administered by experienced examiners, including the authors of this paper and graduate assistants. Each problem solving and creativity task required approximately 10 minutes to administer, including introduction, directions, example items, and three to five minutes of actual work time per task. The project lasted approximately two months in the spring of 1976. The children were tested once per week in their regular classroom settings. Teachers were generally present during testing and aided in the administration of the measures. Testers for a particular group were rotated at regular intervals to minimize any systematic effect due to individual experimenter rapport or style. Finally, all measures were scored by these same testers. Interjudge reliabilities were computed and questionable responses were often discussed among the testers to reach a consensus.

* The authors wish to express appreciation to Dr. Stanley Seidman, principal, and the teachers at Hunter College Elementary School for their cooperation during the course of the study.

Selection of Creativity and Problem Solving Measures

Many of the published instruments available could not be used in the present study. They had been used by other researchers who had conducted experiments with the children in this laboratory school. Therefore, new puzzles and tasks unfamiliar to the teachers and children were gathered (Houtz & Speedie, 1976; Speedie, Treffinger & Houtz, 1976) or developed specifically for use in the present project. Alternate forms of each task were constructed and administered to provide some index of task reliability.

The following tasks were employed:

1. Divergent Thinking
    a. Word Fluency--Making words from ANTELOPES. Children were asked to make as many words as possible from the letters in the word ANTELOPES. Alternate form: LOCOMOTIVES.
    b. Associational Fluency--Meanings. Children were asked to think of as many words as possible that meant the same thing or almost the same thing as "Happy." Alternate form: "Hard"
    c. Ideational Fluency--Uses for Plastic Trays. Children were asked to think of as many possible uses for little clear plastic trays originally used to hold cuts of meat in supermarkets. Alternate form: Ways to make a new student feel at home and make friends.

d. Spontaneous Flexibility--Simply a count of the number of different types or categories of responses to the ideational fluency tasks. A measure of the variety of ideas generated.

e. Expressional Fluency--Making Sentences. Children were asked to make as many as possible four-word sentences, with the four first letters of each word specified: "LMST". The alternate form was "GEPO".

f. Adaptive Flexibility--Making Boxes. Children were asked to cross out lines in a complex pattern of boxes (Matchsticks Problems) to reduce the number of boxes to a specified number, without any extraneous lines remaining. Each form contained six separate problems.

2. Problem Solving

a. Problem Sensitivity (Guilford, 1967; Torrance, 1966)--Busses. Children were asked to suggest as many problems as possible that might happen with busses. Alternate form: Painting something.

b. Patterns--Children were presented with four words and asked to identify as many similarities or relationships in letters, length, sound, meaning among the words as possible. Each form contained two sets of four words (Guilford, 1967).

c. Preparation (Johnson, 1972)--Getting Ready to Solve Problems. Children were presented a

situation in which their school was to take part in a debate. Each classroom would be sending a delegate to speak to the issues. The children were asked to think of as many things as possible that they could do to get themselves and their prospective delegate ready to suggest good ideas.

d. Chaining of Problem Elements--Spy Problem (Speedie, et al, 1976). Children are presented with a list of name pairs. They are told that the task is to pass a secret message from one person in the list to another. The beginning and ending names are given. However, these two "spies" cannot talk directly to one another. Only the names in the name-pairs can talk directly to one another. Therefore, the children must try to find a name-path through the pairs from the first spy to the given end spy. There are several available paths. Alternate form: A second problem.

e. Reorganization of Problem Elements--Buying Animals (Speedie, et al., 1976). Children are asked to spend a given amount of money, no more or less, by buying different animals in the appropriate quantities. The prices of the animals are given and the task becomes one of figuring out how many of each animal can be bought provided at least one and no more than a specified number of each kind of animal is purchased. Alternate form:

A second problem. (Note In both forms, there are several possible answers.)

f. Evaluation of Ideas (Johnson, 1972). Children are presented with a fictitious answer to the New Student Problem (Ideational Fluency) and asked to think of as many reasons as possible why the idea is a good one. Alternate form: Poor Ideas.

Achievement tests were administered to all the children as part of the regular testing program of the school during the 2 month period in which the experimental data were collected. Stanford Achievement Test scores for word meaning, paragraph meaning, arithmetic computation and arithmetic concepts were made available to the experimenters.

Results

Reliabilities of the Measures

Table 1 presents the results of alternate-form estimates of task reliabilities in the present study. Only moderate equivalences between alternate forms were obtained. It appears that it is not easy to develop tasks which, while on the surface appear to be structured in the same way, will assess similar skills and abilities. This has been a consistent problem in the field of creativity and problem solving (Treffinger, Renzulli & Feldhusen, 1975). On the one hand it seems imperative that theory development proceed from data gathered with stable and invariant measures. However, the nature of the creative product and the process which gives rise to it may not be stable.

Table 1

Reliabilities of Creativity and Problem Solving Measures

Measures	r_{ab}
Word Fluency	75
Associational Fluency	59
Ideational Fluency	66
Spontaneous Flexibility	42
Expressional Fluency	60
Adaptive Flexibility	76
Preparation	--
Problem Sensitivity	60
Evaluation of Ideas	67
Spy Problem	55
Patterns	--
Buying Animals	66

In other words, no two tasks, no matter how similar in design, may give rise to the same creative activity. Since the tasks are not identical, there is a good chance that different experiences may be called upon. Particularly unique or novel combinations of problem elements may occur in one situation and to a very different degree in another situation.

Measures of interjudge reliability were also prepared. In the present study, samples of 20 papers for each task were rescored by a second rater. No interrater reliability estimates ranged below .90. One may conclude that, at least, the ideas generated in response to a single task or problem are at least agreed to as relevant and appropriate responses by more than one observer. This type of information may provide sufficient basis for interpretation of the results to follow in this chapter.

Separate Analyses of Variance

Table 2 presents the results of the univariate analyses of variance of grade differences on all of the tasks common to second- through sixth-graders. There were significant effects on all tasks. Table 3 presents the means and standard deviations and Table 4 indicates the patterns of significant mean comparisons for each measure. It appears that significant increases in performance on the creativity and problem solving tasks take place between second and third, and third and fourth grades, but then a plateau is reached, where fourth, fifth, and sixth grades do not increase performance significantly. On the other hand, on the achievement measures, significant increases

are evident between all grade levels. In Table 3, these plateaus are shown by the underlined means, indicating no significant differences between the means.

The Patterns, Spy Problem, and Buying Animals tasks were examined for the fourth through sixth grades. Tables 5, 6, and 7 present the results of these comparisons. Growth occurs between fourth and sixth grades, except for the Spy Problem.

Comparisons with Non-Gifted Children

Data on several of the same problem solving and creativity tasks were available from an earlier project (Houtz & Speedie, 1976). The children, however, were normal-intelligence fifth graders from a middle socioeconomic background and suburban area. Table 7 presents their scores, and comparison of their scores with those of the gifted children (Tables 3 and 5) indicates that the "normal-range" IQ children are performing in the fifth grade at the same levels achieved by the gifted children in the third and fourth grades. Even though some of the fifth graders' scores are larger than the gifted fourth and fifth graders, recall that the gifted children appear to begin a plateau at the fourth grade, from which few differences appear further between fourth and sixth grade.

Table

ANOVA by Grade Level for All Cognitive Measures Using Grades 2-6[1]

Variables	MS	F	w^2
Associational Fluency	68.52	8.77	15
Word Fluency	832.70	23.83	33
Ideational Fluency	418.19	21.23	30
Spontaneous Flexibility	42.45	18.45	27
Expressional Fluency	132.17	20.40	27
Adaptive Flexibility	27.74	12.62	19
Preparation	70.65	16.12	23
Evaluation of Ideas	27.20	10.59	15
Problem Sensitivity	197.52	15.82	22
Achiev.-Word Mean.	132.89	65.14	55
Achiev.-Para. Mean.	167.47	59.38	53
Achiev.-Arith. Concepts	196.78	67.04	62
Achiev.-Arith. Comput.	193.42	69.09	57

[1]All F ratios are significant, p greater than .01

Table 3

Means and Standard Deviations for Each Grade for All Measures Common to Grades Two Through Six

	Grade:	2	3	4	5	6
Assoc. Fluency	M	3.21	4.50	5.75	5.42	7.19
	SD	2.01	2.65	3.54	2.06	3.40
Word Fluency	M	9.70	13.38	16.54	18.81	22.37
	SD	4.40	5.20	6.35	5.50	8.07
Ideational Flu.	M	3.07	5.33	9.11	10.55	10.26
	SD	1.82	3.70	5.21	6.27	4.60
Spontaneous Flex.	M	2.11	3.02	4.08	4.35	4.67
	SD	1.08	1.38	1.60	1.58	1.98
Expressional Flu.	M	1.78	4.43	5.69	5.68	6.19
	SD	1.72	2.69	2.95	2.77	2.16
Adaptive Flex.	M	1.85	2.50	3.37	3.41	4.15
	SD	.99	1.43	1.59	1.57	1.75
Preparation	M	1.47	2.64	3.77	3.55	5.21
	SD	1.38	1.58	2.74	1.76	2.78
Evaluation	M	1.22	2.17	2.61	2.67	3.42
	SD	.92	1.33	1.64	1.80	2.15
Prob. Sensitiv.	M	2.76	4.27	4.48	8.05	7.32
	SD	1.23	2.10	2.20	6.55	3.07
Achiev.-Wd. Mea.	M	4.48	5.47	6.92	8.18	9.13
	SD	1.20	1.38	1.45	1.55	1.37
Achiev.-Para. Mg.	M	4.44	5.84	7.02	8.63	9.87
	SD	1.02	1.60	1.69	1.91	1.80
Achiev.-Arith. Concepts	M	4.11	5.23	6.05	7.90	10.04
	SD	.81	1.02	1.23	1.99	2.01
Achiev.-Arith. Computation	M	5.01	6.02	6.95	8.85	10.43
	SD	1.20	1.10	1.59	1.97	1.80

Table 4

Patterns of Differences Between Pairs of Grade Means Using Grades Two Through Six

Dependent Measures	Pair-Comparisons
Associational Fluency	2-3, 2-4, 2-5, 2-6, 3-4, 3-6, 5-6
Word Fluency	All combinations except 4-5
Ideational Fluency	All combinations except 4-5, 4-6, 5-6
Spontaneous Flexibility	All combinations except 4-5, 4-6, 5-6
Expressional Fluency	All combinations except 4-5, 4-6, 5-6
Adaptive Flexibility	All combinations except 4-5
Problem Sensitivity	All combinations except 3-4, 5-6
Preparation	All combinations except 4-5
Evaluation of Ideas	All combinations except 3-4, 3-5, 4-5
Achievement-Word Meaning	All combinations
Achievement-Paragraph Mean.	All combinations
Achievement Arith. Concepts	All combinations
Achievement-Arith. Computations	All combinations

Table 5

Means and Standard Deviations for Each Grade for Other Measures Common to Only Grades Four, Five, and Six

Variables	Grades:	4	5	6
Patterns	Mean	7.39	10.35	10.75
	S.D.	3.15	3.25	3.31
Spy Problem	Mean	2.24	2.55	2.52
	S.D.	.99	.94	.98
Buying Animals	Mean	1.68	2.19	3.54
	S.D.	1.70	1.64	1.74

Table 6

ANOVA by Grade Level on Other Measures Common Only to Grades 4-6

Measure	MS	F	p	w^2
Patterns	114.86	11.04	.00	
Spy Problem	1.12	1.19	n.s.	
Buying Animals	26.50	9.30	.00	

Table 7

Patterns of Differences Between Pairs of Grade Means on Tasks Common Only to Grades Four Through Six

Measure	Pair-Comparisons
Patterns	4-5, 4-6 only
Buying Animals	4-5, 5-6 only

Table 8

Means and Standard Deviations of Non-Gifted Fifth-Graders on Some of the Creativity and Problem Solving Measures

Measures:	Mean	S.D.
Word Fluency	13.91	5.36
Ideational Fluency	7.60	3.66
Spontaneous Flexibility	3.30	1.38
Expressional Fluency	6.71	2.96
Adaptive Flexibility	2.80	1.39
Spy Problem	2.69	1.67
Buying Animals	2.67	1.21

Grade Differences Based on Factor Scores

Since all of the univariate analyses were significant, there can be no indication of the most important of the creativity and problem solving measures in characterizing grade differences among the children.

Factor scores were generated for grades four, five and six, which included all the creativity and problem solving tasks; two factors were identified (See Table 9): fluency and evaluative-problem solving. With these scores, analyses of variance by Grade (four, five, and six) were computed. The results are presented in Table 10. No grade differences were observed on the fluency factor, but they were observed on the problem solving factor, where Newman-Keuls Post hoc tests (Winer, 1971) revealed that fourth and sixth graders differed significantly. Therefore, one may suggest that several factors may come together in the later elementary-grade years to make evaluation-oriented skills and abilities highly significant. The curriculum, for example, may become more problem-oriented, with greater emphasis on correct answers. In addition, logical operations may be developing concurrently in children and to a sufficient degree to permit more abstract evaluations of ideas on the basis of alternative criteria. Consequently, fluency skills may become less and less important and fail to improve over these years while problem solving becomes more and more important.

Table 9

Factor Loadings Using Only Creativity and Problem Solving Tasks in Grades Four, Five, and Six(N=127)

Variables	Factors:	1	2	h^2
Associational Fluency		63	17	36
Word Fluency		44	49	36
Ideational Fluency		68	-05	33
Spontaneous Flexibility		53	18	31
Expressional Fluency		44	23	25
Adaptive Flexibility		09	56	29
Spy Problem		21	28	13
Patterns		27	31	23
Buying Animals		00	78	37
Percent Variance		31.9	15.6	
Eigenvalue		2.87	1.40	

Table 10

ANOVA by Grade on Factor Scores Derived from Factor Analysis Using Only the Creativity and Problem Solving Measures Common to Grades Four, Five, and Six

Source		Factor 1 (Fluency)		Factor 2 (Reorganization)
Grade	MS	.543	(df=2)	6.70
	F	-		15.37
	P	n.s.		.01

Results of the Profiles of Performances Across Different Tasks

On the basis of standard scores computed for each task for each grade level, a profile of scores for every child on all of the creativity and problem solving tasks was obtained. Performance by each child on a task was then categorized as either falling one-half of a standard deviation above the mean or more, one-half of a standard deviation below the mean or lower, or within one-half of a standard deviation of the mean. The results of this procedure are presented in Table 11.

It is clear that the majority of children demonstrate strong and weak points rather than consistently strong, weak, or average performance across all tasks. In fact, the consistent performers were a very small minority. Slightly more than one-third of the children exhibited the full range of performance categories, and this phenomenon appears to be more pronounced as the children get older. The fifth and sixth graders appeared to display this variability at twice the rate of the younger children.

Taken together, these results clearly show that, despite their intellectual giftedness, there are a number of skills in the creativity and problem solving area which may be developed more fully. In addition, the most important time for this attention to creative and problem solving training may be in the later elementary years, where curricular changes or emphases may result in a focusing on of a few skills, to the exclusion of others.

Table 11

Percentages of Children Demonstrating Different Ranges of Performance

Category Range	Grades 2-4	Grades 5-6	Totals
Lowest to Highest	24	50	36
Only Two Adjacent Categories	66	48	58
Only One Category on All Tasks	10	2	6
Number of Children	134	107	241

Discussion

Torrance (1975) has reported a phenomenon termed "the fourth-grade slump" in children's creative thinking abilities. While the slump is not common to all children (i.e., different cultural or ethnic groups), it has been demonstrated in the United States in many studies. In addition, the "slump" is not only limited to the fourth grade, but also appears at regular intervals in junior high and late high school. Torrance attributes these slumps to changing emphases in school curricula.

The gifted children in the present study do not appear to slump; what does appear by the third and fourth grades is a "plateau" after which no significant growth is achieved. One immediate explanation for these results is that the tasks, themselves, are not sufficiently complex to challenge the fifth and sixth graders. A second possibility is that the time limits imposed on the tasks restricted production of ideas; that is, only so many ideas could be expressed in the time provided that fourth, fifth, and sixth graders simply did not have enough time to differentiate themselves.

An additional interesting finding was that the non-gifted fifth-graders were performing at levels equal to the gifted third and fourth graders or the plateau levels of the gifted children. One may conclude from this that the gifted children are operating one to two years ahead of the non-gifted children in the area of creativity and problem solving and so may have "missed" the traditional slump. It is unlikely that a possible slump occurred earlier for the gifted children,

however, since there also appears a steady progression of scores from second to third and from third to fourth grades. If one considers the nature of the divergent thinking exercises, it is quite possible that the youngest children had the greatest difficulty, first comprehending the tasks, themselves, and then expressing their ideas in the time allowed. Thus, in the case of the fluency-oriented tasks at the early grades, it may be more appropriate to provide additional practice exercises, longer time limits, and alternative response formats.

With the fourth through sixth graders, however, such an explanation of the results is not sufficient. Grade differences were not observed on the fluency factor, but were observed on the problem solving factor between the fourth and sixth graders. Such a contrast may point up the importance of the development of new skills of evaluation and problem restructuring that were not emphasized in the earlier grades or could not be accelerated there because of normal Piagetian developmental processes (Flavell, 1963). Evaluation of ideas or consideration of several problem elements in various combinations at one time cannot be effectively carried out without the requisite cognitive logico-deductive schema which begins to function during the period of formal operations (ages nine and ten and beyond--grades four and beyond). Fluency tasks would not require such operations and so no significant developmental differences were observed on this factor in the later grades. As in other schools, there are considerable differences in curriculum in the later grades in the Hunter School. The curriculum becomes more

content-oriented in the fourth, fifth, and sixth grades. Such a situation may demand from students a great deal more evaluative and problem solving skill and, thus, provide for the eventual appearance of grade-level differences.

A final set of data is also highly suggestive of this effect. To a much greater degree than in the earlier grades, children in the later grades display a range of performances on different puzzles and creativity tasks. There are tasks on which a child scores well above the average and then the same child will score well below average on different tasks. This occurred to a much less degree in the earlier grades. Children in second, third, and fourth grade were much more consistent in their performance across tasks. One might conclude from this that the curricular emphases in the later grades become reinforcing of a more limited set of skills. The "out" skills may atrophy or actually be extinguished during the later years.

The results of the present study appear to indicate that, while gifted children perform at higher levels than non-gifted children, they are by no means free of the influence of normal developmental processes. Of importance also is the lack of evidence in the early elementary grades of a "slump" in creative development. The findings do indicate, however, the potential for continued growth in the later elementary years provided complex and motivating tasks can be found. In addition, it appears that the distinction between creativity and problem solving becomes more crucial in the later grades. Changing curricular demands may, in fact, be retarding the continued

growth of some skills and focusing on a more narrow range of skills than in the earlier grades.

For these reasons, it would seem fruitful to introduce creativity and problem solving materials and training in an attempt to incorporate them into the current curriculum. Teachers may, in fact, have a whole new field available to them for inclusion into the curriculum of the later elementary years. Indeed, unless they do consider this area seriously, the creative thinking skills of some of the children may atrophy or never develop to their potential level.

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